VERTEBRATE PALEONTOLOGY

An Introduction to the Study of

FOSSIL REPTILES

By

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Lexington, Kentucky.
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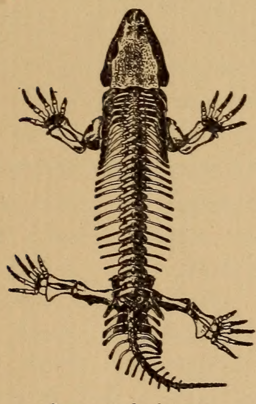

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Baron Georges Léopold Chrétien Frédéric Dagobert Cuvier is the acknowledged "father" of the science of paleontology. He was born August 23, 1769 at Montbéliard, France, the son of religious refugees from the Jura. He early showed an unusual inclination toward the investigation of natural phenomena and was noted for his studious habits and marvelous memory. After four years at the Academy of Stuttgart, he went to Paris where in 1795 he was appointed assistant professor of comparative anatomy at the Museum d'Historie Naturelle. In 1796 he read his first paper on a paleontological subject, *Mémoires sur les Espèces d'Eléphants Vivants et Fossiles,* before the National Institute. This paper was published in 1800. His studies were devoted principally to the mollusca, the fishes, the fossil mammals and the reptiles. His voluminous publications present their systematic classification and relation to living forms. He died, after a short illness, May 13, 1832, at Paris, the world's *first* great paleontologist. CUVIER

Sir Richard Owen, the noted English biologist and paleontologist, was the immediate pioneering follower of Cuvier. He was born at Lancaster, July 20, 1804, and died at London, December 18, 1892. While occupying himself considerably in the field of invertebrate work, it was in *vertebrate paleontology* that Owen made his greatest contribution. Many of his works are standard today though his terminology has not always been accepted. OWEN

Next in sequence of importance and time comes Professor Othniel Charles Marsh. He was born October 29, 1831, near Lockport, New York and died, March 18, 1899 at New Haven, Connecticut. Marsh was the first and greatest of American vertebrate paleontologists. At the time of his death the Peabody Vertebrate Paleontological Collection at Yale University, assembled by Professor Marsh, was the greatest and most complete in the world. MARSH

Living at the same time and producing almost as large and varied a contribution to vertebrate paleontology in America was Professor Edward Drinker Cope. He was born in Philadelphia, Pennsylvania, July 28, 1840, and died there April 12, 1897. He explored in the field, during the period 1871 - 1877, the Cretaceous beds of Kan- COPE

sas, and the Tertiary of Wyoming and Colorado. During his life time over 600 vertebrate species of loose or unknown definition were made known to science by Cope. Among these were not only the wonderful procession of Cretaceous animals of great size, but also many smaller and rarer species. He secured and described from New Mexico some of the oldest known American mammalia.

LEIDY

Third and last in this order of the early great vertebrate Paleontologists of America was Joseph Leidy. He was born September 9, 1823, in Philadelphia, Pennsylvania, where he died April 30, 1891. Leidy's papers covered a wide range in the biologic and paleontologic fields extending from microscopic forms of animal life to the higher and larger vertebrates. However, like his colleagues Marsh and Cope his contributions of greatest length and worth were those which described the Cretaceous vertebrate faunas of the western United States.

AMERICAN VERTEBRATE PALEONTOLOGISTS.

There are, at the present time, about forty vertebrate paleontologists of acknowledged reputation in the United States, and about one hundred in the world. Of the living American vertabrate paleontologists the following are the most prominent: Henry F. Osborn, Columbia University and The American Museum of Natural History; William B. Scott, Princeton University; Richard S. Lull, Yale University; William K. Gregory, Columbia University; William D. Matthew, American Museum of Natural History; Barnum Brown, American Museum of Natural History; Earl Douglass and O. A. Peterson, University of Pittsburgh; J. W. Gidley and Charles W. Gilmore, National Museum; E. C. Case, University of Michigan; E. S. Riggs, Marshall Field Museum of Natural History; E. H. Barbour, University of Nebraska; F. B. Loomis, Amherst College; J. C. Merriam, University of California; Samuel W. Williston, University of Chicago; Oliver P. Hay, National Museum; Roy L. Moodie, University of Illinois Medical School; L. M. Lamb, Canadian Geological Survey; F. A. Lucas, American Museum of Natural History; W. J. Sinclair, Princeton University; J. L. Wortman, formerly at Peabody Museum, Yale University; Walter Granger, American Museum of Natural History; Charles R. Eastman, Harvard University, and the late J. B. Hatcher, of the Carnegie Museum.

TEXTS.

Of the vertebrate texts in use there are several, any one of which covers special portions of the field exceptionally well. Karl A. von Zittel's, *Die Grundzüge der Paläontologie,* however, is the only reliable general and comprehensive work. The English translation of the vertebrate section of Zittel by Charles R. Eastman has been completed and published through the fishes, amphibians, reptiles and birds, but the volume on the mammals has not yet appeared. Professor Williston's *"Water Reptiles of the Past and Present"* is a splendid and up-to-date work in the special field of reptiles, as is this same author's *American Permian Vertebrates.* Dr. Osborn's *The Age of Mammals,* and Professor Scott's *A History of Land Mammals in the Western Hemisphere* are both excellent and thoroughly systematic texts. A readable, though not very up to date text is: Henry A. Nicholson and Richard Lydekker's *A Manual of Paleontology,* volume 2, London, 1889. Other good German works are O. Abel's, *Grundzüge der Palaeobiologie der Wirbeltiere;* Guztave Steinmann's *Elemente der Paläontologie* and K. H. Stromer's *Lehrbuch der Paläzoologie,* Part I, Wirbellose Tiere.

COLLECTIONS.

The best North American collection of displayed and stored vertebrate fossils is located at the American Museum of Natural History in New York City. The Yale University vertebrate collection now ranks second, though up until the last few years, it was the largest and most complete in the United States. There is a very good vertebrate collection at Princeton University. An excellent collection of vertebrate fossils is also to be found at the National Museum in Washington, D. C. The best collection of Permian reptiles is in the Walker Museum at the University of Chicago. The Universities of Kansas and of Nebraska have good vertebrate collections. The University of Wyoming has a splendid stored collection but none mounted. There is a large mounted collection at the University of California at Berkeley and also at the University of Toronto. A fine collection of vertebrates has also been acquired by the Canadian Geological Survey at Ottawa. Harvard like many other American Universities has practically no vertebrate collection at all. The best collections of vertebrate fossils in the world are now distributed throughout the United States and, for this

reason, the seat of the most important research work in this science is located here. A generation or so ago several European Universities lead by Munich, stood in the forefront of the rapidly advancing field of vertebrate paleontology.

EARLY VIEWS.

The study of vertebrate paleontology may properly be said to have begun in the days of the old Roman Empire with Caesar's collection of fossil bones. In the 14th and 15th centuries fossil vertebrates were thought to be "sports of nature." In the 17th and 18th centuries the old theory of "sports" was discarded, and a new idea that these fossils or animals grew in the rocks came to take its place. As late as the 18th century it was popularly believed that vertebrate fossil remains represented animals that had been drowned in the great Biblical flood. This discarded view is now spoken of as "the ante-deluvian theory."

DARWIN AND EVOLUTION.

Early in the nineteenth century, Charles Darwin and Jean Lamarck replaced these earlier lines of thought with their theories of evolution. Development along this new idea of progressive change of species then became rapid. It has been said that Cuvier would frequently determine the genera of an animal by the study of one or two bones. Subsequent isolated instances of accuracy in this sort of determinative work can be cited, but today it is generally regarded as a rather loose practice unless another perfect skeleton is available for close comparison.

SYSTEMATIC NOMENCLATURE.

The so-called "Binomial System" of nomenclature, now used generally throughout vertebrate paleontology, is modern. The scheme employed in this: One name is used with an adjective which is descriptive. Thus the name became the genus and the adjective the species. Then came the grouping into families, and to indicate this family grouping the ending (idae) became fixed. The nomenclature used in vertebrate paleontology, as distinguished in species, is based upon the natural philology which, in turn, is fundamental with evolution. The gaps between the mammals are closed in many cases and in some instances very perfect gradations from the earliest ancestral forms to those of the living species have been worked out. But the classification now in use depends largely upon the concensus of opinion of a few very specialized experts in

restricted fields. An instance of this is seen today in the four groups of Mesozoic reptiles. Into these four groups, by the means of careful and systematic classification, over 40,000 described species have been placed.

The following division of the vertebrates into distinct classes has become established.

CLASSIFICATION AND READING REFERENCES

Class I. The AGNATHEA: The Crustacean-Ostracoderm Quasi-Vertebrates. (Chamberlin and Salisbury, Vol. II., pp. 482-486). All fossil forms.

Class II. The PISCES: The Fishes. (Pirsson and Schuchert, Vol. II., pp. 678-694). Living and fossil forms.

Class III. The AMPHIBIA: The Frogs, Toads, Salamanders, Stegocephalia, etc. About 900 living species and 575 extinct fossil species have been described. (Pirsson and Schuchert, Vol. II., pp. 797-804).

Class IV. The REPTILIA: The Lizards, Turtles, Crocodiles, Snakes, Dinosaurs, etc. There are about 4,500 living species, and about 500 extinct species described. (Pirsson and Schuchert, Vol. II., pp. 804-810, 827-828, 831-843.) Additional references: *Water Reptiles Past and Present,* Williston; *American Permian Vertebrates,* Williston; *Permo-Carboniferous Vertebrates From New Mexico,* Williston, Case and Mehl; *Dinosaurs,* Matthew; and Eastman's translation of Zittel's *Die Grundzüge der Paläontologie,* Vol. II., pp. 140-255.

Class V. AVES. The Birds. There are about 12,000 living species and about 500 extinct species. (Pirsson and Schuchert, Vol. II., pp. 854-856.) Additional references: Eastman's translation of Zittel's *Die Grundzüge der Paläontologie,* Vol. 11, pp. 256-278; *Creatures of Other Days,* Hutchinson, pp. 150-173; *Extinct Monsters,* Hutchinson, pp. 213-224.

Class VI. MAMMALIA: The Dogs, Sheep, Horses, Men, etc. There are about 3,000 living species and about 1,000 extinct species described. References: *The Age of Mammals,* Osborn; *A History of Land Mammals of the Western Hemisphere,* Scott; *Extinct Animals,* Lancaster, pp. 103-189; *Exinct Monsters,* Hutchinson, pp. 135-212, 225-234. Popular, *Creatures of Other Days,* Hutchinson, pp. 174-253. *Evolution of Mammalian Molar Teeth,* Osborn: *Tertiary Vertebrata,* E. D. Cope, U. S. G. S. Report 1884, Hayden Survey.

CONTRASTED FIELDS

While paleontologic knowledge is full and growing for some groups, it is lean and almost dormant in other branches. More investigation has been made in and more papers have been written on the mammals than on all the other classes of extinct vertebrates. Much has been written on the reptiles, and this is a growing field, but the mammals have the lead in present investigation and will probably continue to hold it. On the other hand little has been written on the lower vertebrates, with the exception of the fishes, and probably little will be done for it is not a field that will allow of much expansion because of the lack of material. All that workers in vertebrate paleontology have to use are the bones or hard parts of the extinct animal. In a few and very rare instances the skin and the hair may leave its impression. Fossil flesh has never been found except in the case of a very few late Pleistocene or Sub-Recent Mammoths.

The structure of the vertebra, irrespective of size, gives the key to the probable classification of an animal-skeleton. e. g.

VERTEBRAL STRUCTURE

Vertebra with the concavity in front are PROCOELUS.

Vertebra with the concavity in rear are AMPHOCOELUS.

Vertebra with no concavity, but flat, are PLATYCOELUS.

Vertebra with double concavity are OPISTHOCOELUS.

All erect walking mammals are Platycoelus. All snakes develop the additional articulating vertebral dentition called "the *zygosphene*." Pterodactyls were the first Procoelus animals. Crocodiles and lizards were the first Amphocoelis animals, and did not become Procoelus until the Cretaecous. Only land animals become Procoelus. The Mososaurs are Procoelus but are a reverting-to-water type. Dinosaurs are Opistocoelis, and like snakes the Cotylosaurus and a few other amphibious Stegocephalians have the extra articulating dentition of the zygosphenal type on the vertebra.

VERTEBRAE NAMED

The kinds of vertebra by name are: Cervical, Dorsal, Lombar, Sacral, and Caudal. The Sacral vertabra are from two to three in number and bear ribs for the support of the pelvis. They are usually heavier than the others for this reason. No living animal except crocodiles have ribs on the atlas. "Seymouria" has but one sacral vertebra

and thus represents a primitive type. Carnivores have two sacral vertabra; man, five; birds, ten - fifteen. Snakes show the maximum maker of vertebra attaining as high as five hundred. Turtles exhibit the minimum with thirty.

CLASSIFICATION OF FOSSIL REPTILES

INDEX TO STRATIGRAPHIC RANGE

Order I.

RHYNCHOCEPHALIA. (Extinct and living primitive lizard-like reptiles.)

Sub-order 1.

PROTEROSAURIA.

PALAEOHATTERUS. Lower Permian.

Sub-order 2.

COTYLOSAURIA.

NOTHODON (Diadectes) Permian.

LIMNOSCELIS. Permian.

SEYMOURIA. Permian.

Sub-order 3.

PELYCOSAURIA.

DIMETRODON. Permian.

NAOSAURUS. Permian.

EDAPHOSAURUS. Permian.

CASEA. Permian.

MESOSAURUS. Karoo-Mesozoic.

Sub-order 4.

RHYNCHOCEPHALIA VERA.

MESOSAURUS. Karoo-Mesozoic.

SPHENODON. Triassic to Recent.

Order II.

SQUAMATA. (Extinct reptiles, lizards and snakes.)

Sub-order 1.

DOLICHOSAURIA.

DOLICHOSAURUS. Upper Cretaceous.

Sub-order 2.

PYTHONOMORPHA.

PLATECARPUS. Upper Cretaceous.

MOSASAURUS. Upper Crateceous.

Sub-order 3.

Lacertilia. (Lizards.)
Glyptosaurus. Lower Eocene.
Sub-order 4.
Ophidia. (Snakes.)
Paleophis. Lower Eocene.
Heteropython. Miocene.

Order III.
ICHTHYOSAURIA. (Extinct Marine reptiles).
Ichthyosaurus. Triassic to Cretaceous.

Order IV.
SAUROPTERYGIA. (Primitive aquatic reptiles.)
Nothosaurus. Triassic.
Plesiosaurus. Triassic to Cretaceous.

Order V.
THEROMORPHA. (Primitive land reptiles.)
Sub-order 1.
Pareiasauria.
Pareiasaurus. Permian to Triassic.
Sub-order 2.
Sphenacondonia.
Clepsydrops. Permian.
Sphenacodon. Permian.
Varanosaurus. Permian.
Sub-order 3.
Theriodonta.
Lycosaurus. Karoo-Mesozoic.
Sub-order 4.
Anomodontia.
Dicynodon. Karoo-Mesozoic.
Sub-order 5.
Placodontia.
Placodus. Triassic.

Order VI.
CHELONIA. (Extinct and living turtles).
Sub-order 1.
Trionychoidea.
Trionyx. Miocene.

Sub-order 2.

CRYPTODIRA.

EOSPHARGIS. Eocene.
PROTOSTEGA. Upper Cretaceous.
ARCHELON. Cretaceous.
LYTOLOMA. Upper Cretaceous and Eocene.
TROPIDEMYS. Jurrasic.
CHELYDRA. Miocene to Recent.
ADOCUS. Cretaceous.
STYLEMYS. Oligocene to Pliocene.
HADRIANUS. Eocene.
TESTUDO. Miocene to Recent.

Sub-order 3.

PLEURODIRA.

PLESIOCHELYS. Upper Jurassic.

Sub-order 4.

AMPHICHELYDIA.

PLATYCHELYS. Upper Jurassic.

Order VII.

CROCODILIA (Triassic to Recent Reptiles).

Sub-order 1.

PARASUCHIA.

PARASUCHUS. Triassic.

Sub-order 2.

PSEUDOSUCHIA.

TYPOTHORAX. Triassic.

Sub-order 3.

MESOSUCHIA.

TELEOSAURUS. Jurassic.
ATOPOSAURUS. Jurassic.

Sub-order 4.

EUSUCHIA.

THORACOSAURUS. Upper Cretaceous.
GAVIALIS. Eocene to Recent.
ALLIGATOR. Recent to Present.

Order VIII.

DINOSAURIA. (Extinct Mesozoic Reptiles.)

Sub-order 1.

THEROPODA. (Carnivores.)

ANCHISAURUS. Triassic.

Creatosaurus. Upper Jurassic.
Allosaurus. Upper Jurassic.
Hallopus. Upper Jurassic.
Thecospondylus. Triassic to Upper Jurassic.

Sub-order 2.

Sauropoda. (Herbivores).

Camarasaurus. Upper Jurassic.
Morosaurus. Upper Jurassic.
Apatosaurus. Upper Jurassic.
Brontosaurus. Upper Jurassic.
Titanosaurus. Cretaceous.
Diplodocus. Upper Jurassic.

Sub-order 3.

Predentata. (Herbivores)

Camptosaurus. Upper Jurassic.
Iguanodon. Upper Jurassic to Cretaceous.
Trachodon. Upper Cretaceous.
Stegosaurus. Upper Cretaceous.
Triceratops. Upper Cretaceous.
Ceratops. Upper Cretaceous.

Order IX.

PTEROSAURIA (Extinct air-bourne reptiles)

Sub-order 1.

Pterodermata.

Dimorphodon. Lower Jurassic.
Rhamphorhynchus. Upper Jurassic.

Sub-order 2.

Ornithocheiroidea.

Pterodactylus. Jurassic.
Myctodactylus. Cretaceous.
Pteranodon. Cretaceous.
Ornithocheirus. Lower Cretaceous.

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